The effective technology for water purification is PolyAluminium Chloride (PAC)

Installations for Coagulant Production

$(Al_n (OH)_m Cl_{3n-m})X$

De Dietrich
PROCESS SYSTEMS

The coagulants for water purification

Metallic salts and their derivative products are widely used as effective coagulants for drinking water, swimming pool water, industrial and waste waters treatments.

In case of drinking water treatment, aluminium salts are better because of residual iron which causes staining effect and filter blocking problems by using ferric salts.

The most commonly used coagulants for the removal of water impurities are the following metallic salts:

- Aluminium sulphate: $Al_2(SO_4)_3 \bullet 18\ H_2O$
- Iron chloride: $FeCl_3 \bullet 6\ H_2O$
- Ferric sulphate: $Fe_2(SO_4)_3 \bullet 9\ H_2O$
- Ferrous sulphate: $FeSO_4 \bullet 7\ H_2O$
- Sodium aluminate: $NaAlO_2$

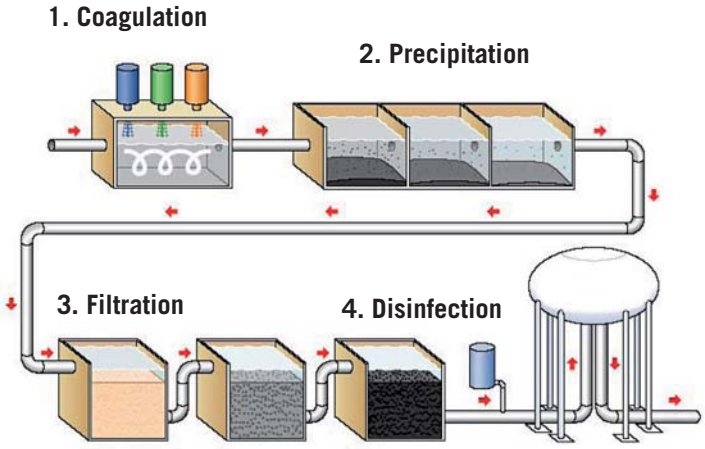
The most efficient coagulant based on metallic salts is:

- PolyAluminium Chloride (PAC): $Al_n(OH)_mCl_{3n-m}$

As well as its mixed salt with aluminium sulphate:

- PolyAluminiumSulphate Chloride (PACS): $Al_n(OH)_m\ (SO_4)_3\ Cl_{3n-m-2x}$

Due to the high coagulation power of these added reagents, the suspended water impurities group and are capted together for forming small and unstable agglomerates. With the addition of a flocculent product, those agglomerates grow in order to form big stable flocs, which precipitate and are eliminated through the filtration step.



In water treament process, the original stream includes the following physical and chemical treatments.

1. Under the influence of the added coagulant, the fine suspended water particles group together and form small and fragile agglomerates. The addition of an another chemical reagent called flocculent allows the formation of bigger and stronger agglomerates called flocs, which are more easily filterable.
2. Precipitation: The formed flocs in step «1» precipitate under their own weights
3. Filtration: The water flows through the filtering cloth which separates the solid agglomerates and the liquid
4. Disinfection: Elimination of the biological contamination (Bacteria, pesticide...) with a chemical treatment
5. Distribution of the purified water to the consumers.

Glass-lined Equipment

PolyAluminium Chloride production is one of the most exigent process for glass lined equipment due to its high corrosive and abrasive effect.
That's why, the experience and the qualification of De Dietrich allows to meet qualitatively those process requirements.

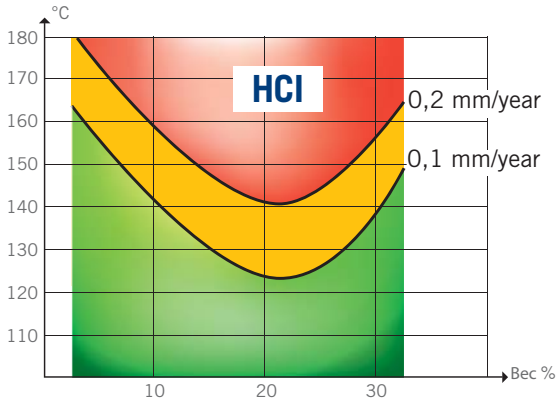
Over 30 years, we have ever supplied hundreds of glass-lined reactors running for PAC production, which represent the heart and the main critical point of the PAC processes. Through this great experience, we have acquired deep knowledge and competences concerning the PAC process requirements and its characteristics.

The PAC synthesis occurs under high pressure and high temperature. PolyAluminium Chloride is the product of the batch reaction between solid Aluminium Hydroxide ($AL(OH)_3$) and liquid Hydrochloric acid (HCl).

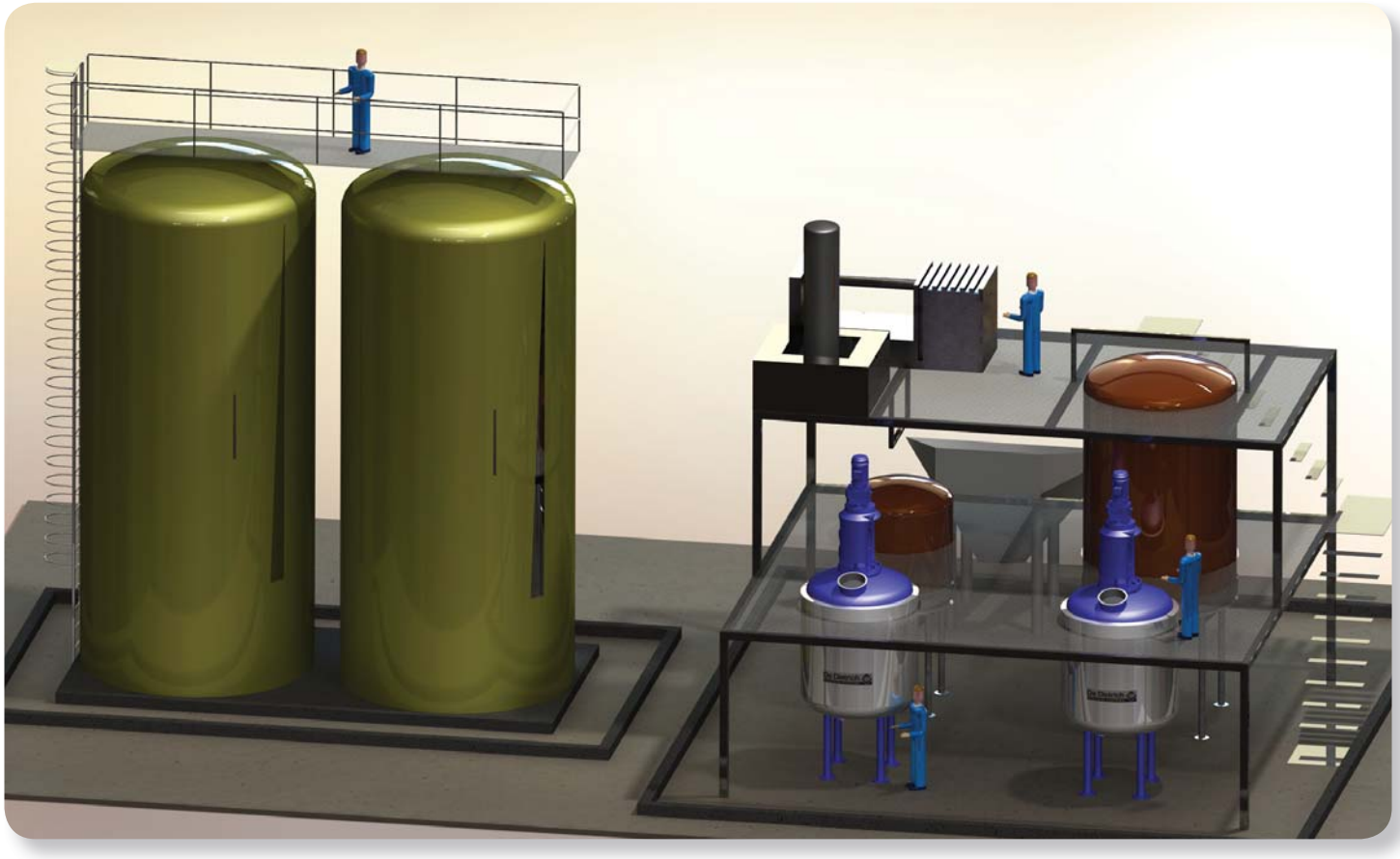
$$Al(OH)_3(s) + HCl\ (l) \rightarrow Al_m\ (OH)_m\ Cl_{3n-m}\ (l)$$

The De Dietrich Enamel is completely dedicated to this highly corrosive and abrasive process and we have also developped specific solutions for the PAC reactor:

- De Dietrich Enamel 3009 HA - Visual Signal with a great resistance against acid environment (HCl)
- Visual detection of the corrosion through different colors of enamel layers
- Adapted Impeller agitator with a special geometry
- Early detection of any corrosion in the reactor thanks to the D.e.Co.S. system.



De Dietrich PAC units



De Dietrich offers a complete range of advanced and dedicated solutions for the PolyAluminium Chloride synthesis and its derivatives for different PAC productions: PAC 14%, PAC 18%, PACS 10%.

Our scope of supply includes:

- A dedicated glass-lined reactor
- Basic and detailed engineering
- Process Optimisation: adapted Impeller agitator, D.e.Co.S. system
- Procurement of reactors, equipment, process control and automation, valves and instrumentation
- Supervision and assistance during the plant erection
- Start-up of the unit and achievement of the full contract.

Our solution ensures process guarantees subject to raw materials quality, operating conditions and equipment quality.

- The PAC unit is based on 2 De Dietrich glass-lined reactors of 16m^3 which can produce 40,000 tonnes of PAC/year.

PolyAluminium Chloride (PAC)

The coagulating power of the added coagulants depends on their chemical nature and their interaction with the media to purify.

Aluminium Sulphate

It comes from the chemical reaction between sulphuric acid and aluminium hydroxide. Its efficiency depends on hydrolisis grade of aluminium. Hydrolisis process starts after dosing the aluminium sulphate into water. Like every chemical reaction the degree of hydrolysis depends on raw water type, reaction time and temperature, etc...

This kind of reactions can be summarized as:

$Al^{3+} + H_2O \leftrightarrows [Al(OH_2)_6]^{3+}$

$[Al(OH_2)_6]^{3+} + H_2O \leftrightarrows [Al(OH_2)_5OH]^{3+} + H_3O^+$

$2[Al(OH_2)_5OH]^{3+} + H_3O^+ \leftrightarrows [Al_2(OH)_2]^{4+} + H_3O^+$

$3[Al(OH_2)_5OH]^{3+} + H_2O \leftrightarrows [Al_3(OH)_4]^{5+} + H_3O^+$

As the process continues the molecular weight of aluminium hydrolisis compounds increases but in any case high molecular weight polymers are not achieved.

The efficiency of coagulation is driven by the presence of high molecular weight aluminium polymers with high density of charge. Using aluminium sulphate the concentration of those reactive molecules is very low and not constant.

Due to its advanced polymeric structure, PAC is a high molecular weight compound which means a high coagulation efficiency.
The concentration and the molecular weight of this polymer will only depend on the chemical process involved in its manufacturing and remain independant of the raw water characteristics.

Advantages of PolyAluminium Chloride:

1. PAC reacts faster than aluminium sulphate because of its polymeric structure which allows a higher coagulation efficiency
2. The formed flocs are bigger which means a faster sedimentation. Moreover, PAC remains effective over a wider turbidity range and even at very low temperatures
3. Lower quantities of residual aluminium in water (compared with the analogous value with aluminium sulphate) reducing consequently health problems (Alzheimer)
4. Reduced cleaning frequence of the filters (longer runs in the sand filters)
5. PAC consumes less alkalinity than the other coagulants. In most cases, there is no need of alkalinity addition for an effective flocculation, so additional pH correction chemicals aren't necessary
6. Lower doses are required for equivalent results in comparison with aluminium sulphate
7. PAC remains efficient over a larger pH range
8. Less sludge production compared to the other coagulants.

Comparative Datas

Coagulant	Reagent pH level	Media (pH) Max efficiency	Aspect	Density of the solution (Kg/m3)	Dosage for drinking water (g/m3)	Dosage for wastewater (g/m3)	Advantages	Limitations
PolyAluminium Chloride $Al_n(OH)_mCl_{3n-m}$	1.0	4.5 - 10	Yellowish liquid	1380	3 - 50	15 - 100	- All water treatment types - Higher water quality - Higher coagulation efficiency - Lower dosage requirements - Shorter flocculation and sedimentation time - Reduced number of washing steps	- Aluminium is corrosive to metals
Aluminium Sulphate $Al_2(SO_4)_3 \cdot 18\,H_2O$	2.7 - 3.7	6.5 - 7.5	White to off-white crystals or power	1330	10 - 150	50 - 300	- Low acidity - Low final water turbidity - Easy to handle and apply	- High residual aluminium quantities - Health problems (Alzheimer) - Irritant powder - Low elimination of Dissolved Organic Carbon (DOC) - Effective over a limited pH range
Iron Chloride $FeCl_3 \cdot 6\,H_2O$	1.8	4 - 11	Dark grey to brown liquid	1430	5 - 150	50 - 300	- Very efficient elimination of organic matters - No residual aluminium - Easy detection of iron residues - Wide pH range	- High residual iron quantities - Very corrosive - Exothermic dissolution - Filter blocking problems
Ferric Sulphate $Fe_2(SO_4)_3 \cdot 9\,H_2O$	<1.0	4 - 8	Red - brown liquid	1550	10 - 250		- Very efficient elimination of organic matters - No residual aluminium - Easy detection of iron residues - Wide pH range	- High residual iron quantities - Very corrosive - Staining product - Basifying product requirement
Ferrous Sulphate $Fe(SO_4) \cdot 7\,H_2O$	1.5 - 2.2		Greenish or yellow brown crystal	1200	5 - 150	100 - 400	- No residual aluminium - Not pH sensitive	- High residual iron quantities - Very corrosive - Staining product - Basifying product requirement - Conservation at T > 10°C
Sodium aluminate $NaAlO_2$	> 14.0	3 - 8	Viscous colorless to amber liquid	1500	5 - 50		- High efficiency in acid waters - Low dosage requirements - High performances	- Very corrosive - Very irritant - Ineffective in some waters - Flammable reaction with ammonium salts

De Dietrich Solutions for PAC Process

- Process Know How
- Basic and detailed Engineering
- Low operation expenses
- Less maintenance
- More safety
- Process guaranties

- Dedicated enamel: 3009HA - Visual signal
  - First layer of enamel white then blue
    - Adapted Impeller Agitator
  - Optimization of the heat transfer

Dedicated Reactor

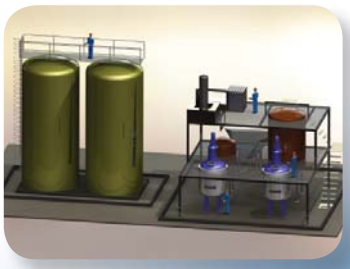
Process Solutions

DE DIETRICH SOLUTIONS FOR PAC PROCESS

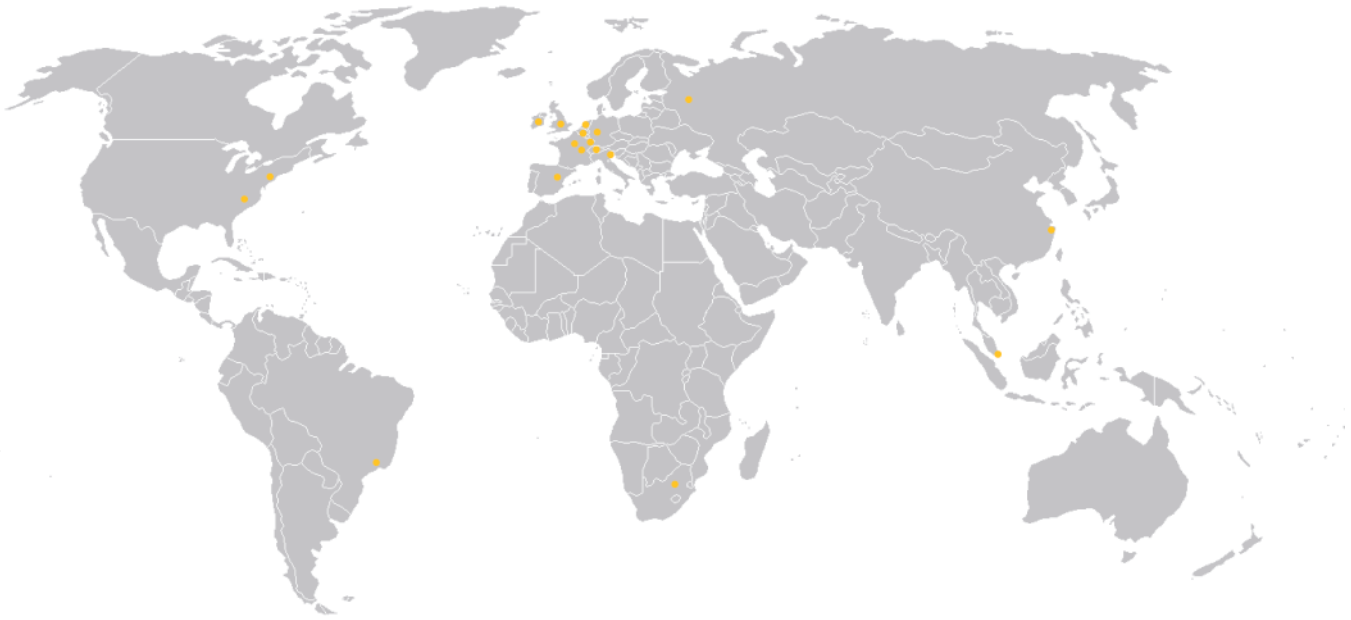
Process Optimization

Engineering Solutions

- 3D Modelling
- Process optimization
- Equipment procurement
- Plant erection supervision
- Commissionning



- D.e.Co.S. to detect the corrosion
  - Adapted Impeller agitator
    - Visual corrosion warning



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The international business group De Dietrich Process Systems is the leading provider of system solutions and reactors for corrosive applications as well as plants for mechanical solid/liquid separation and drying. The system solutions from De Dietrich Process Systems are used in the industrial areas of pharmaceuticals, chemicals and allied industries.

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